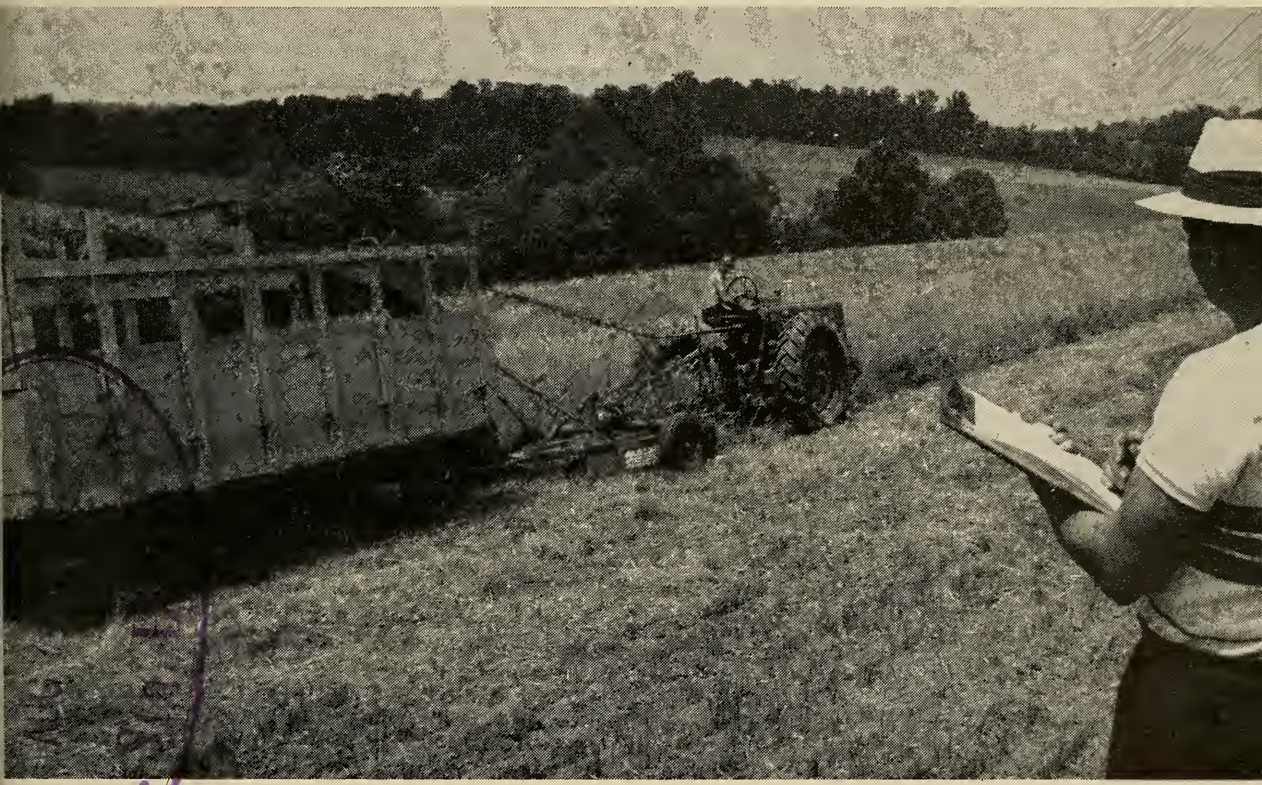
USING FLAIL FORAGE HARVESTERS



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THE COVER

Horizontal rotating flail harvester being timed to fill a wagon. Time of loading was 38 minutes. The load was approximately four tons.

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Introduction

TESTS were set up to gain information needed to properly answer questions concerning the effectiveness of flail forage harvesters on a number of different jobs. It is possible that these harvesters would be desirable for (1) chopping forage for direct feeding, (2) mowing forage for hay, (3) removing hay from the swath, (4) removing hay from the windrow, (5) making silage, (6) pasture trimming, and (7) brush cutting. Objectives of the tests used were to determine the proficiency with which representative machines would perform each of these tasks, as well as the desirable and undesirable features of such machines. Two machines, with representative features of all such machines on the market, were selected for the tests.

Flail Harvester Operation

There are two general types of flail harvesters—one with the flails rotating in a horizontal plane and the other with the flails rotating in a vertical plane. The cutting method of both machines is very much the same—primarily by impact. Tests have shown that the cutting edges of these machines must move at a rate of 9 to 10 thousand feet per minute in order to make a clean cut. One machine used for the tests was designed with sharp cutting edges, and the other had blunt edges. The sharp edges on the one machine were blunted in normal operation by small rocks and other debris after they had been run close to the ground for a short period. This seemed to make little difference in the performance of the machine.

Cutters that were flexible with the rotor were more desirable than those rigidly mounted to the rotor. When the flexible cutters accidentally came in contact with an obstruction, such as a large rock, they would deflect and pass over the rock. In similar situations, the rigid cutters suffered excessive damage (Figure 1).

Some flail cutters trail directly behind the tractor, whereas others are built to trail in an offset position. Those with horizontal rotating flails almost always are trailed behind the tractor. Machines with vertical rotating flails lend themselves better to being trailed in the offset position. Approximately half of such machines, however, are trailed behind the tractor.

FIGURE 1. This 10-pound sandstone, accidentally picked up by a chopper with horizontally rotating flails, removed one of the four knives. Damage to the other three also occurred. The height of cut was approximately four inches.

A test was made to determine the desirability of offset and trailing positions. To do this, the tractor was run through standing forage without the machine. Then the offset machine was pulled over the area in which the forage had been depressed by the tractor wheels. This was then compared with an area in which the tractor had not pressed the forage down. The difference in stubble height in each area was very slight (Figure 2). This indicated that there is very little, if any, difference between the effectiveness of the machine which would trail behind the tractor or the one that trailed to the side.

Direct Feeding

Forage chopped and hauled to feed bunks for feeding to stock is a system of feeding described by several names. Here, it will be called direct feeding. The flail forage harvesters are primarily designed for this type of work.

FIGURE 2. Cutting grass with the vertical rotating flail harvester after making a run over the uncut swath with the tractor to simulate a machine which was not offset. The difference in the length of stubble where the tractor wheels had been was negligible.

Both machines worked proficiently in forage less than one foot high. The horizontal rotating flails were not satisfactory in taller forage (Figure 3). The machine housing would drag the forage over excessively, and on the side where the flails were not moving into the forage, the cut was ragged. This low housing is necessary to direct the material to the discharge spout. The vertical flails would cut clean in any forage so long as the forward speed was not too great. Bulk, rather than height of the material, was the limiting factor on the rate of forward travel. Power requirements would become too high and the stubble too long and ragged when the machine was overloaded with faster forward speeds.

Length of cut was the same for both machines (Figure 4). Some of the forage was cut short. Most of the lengths were approximately six inches. Occasionally they would be as long as 15 inches, but the volume of lengths over eight inches was negligible.

Rates of Cutting

Each chopper would cut a swath 54 inches wide. This was somewhat different from the advertised widths. The housing of the horizontal rotating flail machine was 62 inches wide—the advertised cutting width. Forage would push away from the sides of the housing so as to reduce

FIGURE 3. The swath at left was cut with the vertical rotating flail harvester and the two swaths on the right were cut with the horizontal rotating flail harvester. Overlapping the swath as was done with the horizontal rotating flails improved removal of the forage considerably. Removal by the horizontal flails was still considered unsatisfactory in this dense stand of lodged forage.

the cut swath. Width of the vertical rotating flails was 50 inches—the advertised cutting width. Here, the housing had a tendency to pull the forage toward the flails. This resulted in a four-inch gain in the swath width.

Forward speeds were determined by the density of the crop. With the vertical rotating flail machine, it took 30 to 40 minutes to load a 7 x 14-foot wagon box to a depth of five feet. Five minutes more were required for the horizontal rotating flails (see cover). The longer cut forage of these machines would not pack as much in a wagon as a shorter cut obtained with a conventional field chopper. Approximately one-third more forage could be put into a wagon with a conventional chopper. Where four tons could be loaded with a conventional chopper, three tons could be expected to be loaded with a flail chopper.

Power Requirements

Each machine was checked in the laboratory for power input while running empty at the rated speed. The horizontal rotating flails required 15 horsepower, and the vertical rotating flails required 4.5 horsepower. A large portion of the power which was measured in the laboratory was probably due to air movement through the machines.

FIGURE 4. Grass cut with horizontal rotating flails. No difference could be observed in the forage chopped by the horizontal rotating flails and that chopped by the vertical rotating flails.

For second-cut grass and alfalfa mixture, 10 to 16 inches in height, and at a forward speed of three miles per hour, the horizontal rotating flails required 16 to 17 horsepower, and the vertical rotating flails 10 to 11 horsepower. The crop density would give a yield of dry hay of approximately 1.2 tons per acre. A forward speed of three miles per hour was the maximum for either machine to do satisfactory work; two and one-half miles per hour produced better results. Power tests were run at 1.8 miles per hour and three miles per hour in soybeans that were 30 inches high and would yield two tons of dry forage per acre (Figure 5). The horizontal rotating flails required 22 to 23 horsepower, but removal of the beans from the ground was far from satisfactory. The vertical rotating flails required 13 to 18 horsepower for the slower speed and 14 to 24 horsepower for the faster speed. Performance of this machine was satisfactory at the lower speeds. A two-plow tractor was necessary for the operation of either machine. A three-plow tractor was desirable when the harvester was used with a loaded wagon on rolling ground.

Mowing Hay

The long cut of forage was a desirable length for hay. Fracturing of the stems appeared to give the forage drying characteristics comparable

FIGURE 5. The vertical rotating flail harvester is cutting soybeans and returning them to the ground to be cured for hay. The power for this operation is being indicated by the dynamometer on the power-take-off shaft of the tractor.

to those of crushed forage. Both soybeans and a mixture of brome, orchard grass and timothy were cut with the vertical rotating flail chopper and returned to the ground for curing. The orchard grass and timothy was heavy and lodged. Better cutting was accomplished with the vertical rotating flails in heavy lodged material than with a cutter-bar mower (Figure 6). Stems were fractured in both crops. This indicated that the drying rate would be greater than the drying rate of forage cut with a cutter-bar mower.

Comparisons were made between the drying rate of soybeans cut by the flail harvester and crushed soybeans. Similar drying rates were obtained for a short period. After the top portion of the flail-cut soybeans dried, the rate of drying of the remainder of the crop became very low, so that without some agitation, the lower portions of the soybeans would spoil. The necessary agitation introduced a new factor which prohibited further comparison with crushed soybeans.

Grass dried in the same general pattern as the soybeans. When the grass was not too heavy (less than one ton per acre of dry hay), flail-cut grass would cure faster than grass mowed with a cutter bar. Raking at the proper time (when the top layer was reasonably dry) improved the drying considerably. Flail-cut forage that had been exposed to rain cured more slowly than normally mowed hay. In addition, it was almost impossible to cure such forage satisfactorily. The forage cut by the flail harvester had an increased tendency to pack. A very thin layer on the top would dry (Figure 7), and all forage beneath it had the consistency of a saturated sponge.

FIGURE 6. Comparison of stubble where swaths were cut with the vertical rotating flail harvester and a cutter-bar mower in dense lodged grass. The swath next to the standing crop was cut with the flail-type harvester and the one where the man is standing was cut with the cutter-bar mower.

Losses of the forage cut by the flail chopper due to raking were negligible. A side-stroke rake was used and it was observed that it left no more of the long-chopped forage on the ground than was left on the ground in raking forage that had been cut by the cutter-bar mower. Short pieces would stay in the windrow quite well. The baler would pick up these windrows with good efficiency; however, it was noted that the baler left slightly more long-chopped hay on the ground than it did when picking up hay that had been cut by a cutter-bar mower. When the hay was dry enough for baling (below 40 per cent moisture wet basis), the shorter pieces of the long-chopped material had a tendency to separate from the windrow. Even though these losses were obvious, the quantity of hay lost was negligible.

Removing Hay from Windrow

Forage cut with the cutter-bar mower was partially cured and windrowed. The vertical rotating flail machine was used to chop and load this into a wagon (Figure 8). No attempt was made to use the horizontal rotating flail machine for windrow pickup. The moisture content was about 45 per cent wet basis, and considerable difficulty was

FIGURE 7. Grass cut with a vertical rotating flail harvester and partially dried for hay. The crop was exposed to rain and only the top layer would dry. The tobacco can is for scale. The forage is moved from a small area to show the depth of the swath.

FIGURE 8. Attempting to pick up a windrow with the vertical rotating flail harvester. Estimates of the forage moisture content were 40 to 50 per cent wet basis.

encountered because of plugging of the chopper (Figures 10 and 11). This was a single windrow with somewhat over one ton of dry hay per acre. The feed into the flail chopper was much too fast when the tractor was running in low gear—1.8 miles per hour to maintain PTO speed. The tractor engine horsepower was 34. In order to operate at all, the tractor clutch had to be slipped to reduce the forward speed.

Plugging occurred in the blower. The engine pulled down until the blower was not clearing the discharge spout. This was followed by an abrupt stop. Hay was going through the machine up to the discharge fan (Figure 9). The fan housing was completely full and packed (Figure 10) by the time the machine stalled.

Hay with a moisture content of 45 per cent wet basis gave the maximum amount of wrapping at any point where there was a tendency to wrap. The axle of the fan was a susceptible point and wrapping here may have consumed an excess of power, thereby causing the tractor to begin to stall.

Other conditions also would give the same reactions. A single windrow where the yield was somewhat less than one ton of dry hay per acre was used in one test. Although the moisture content of this windrow was approximately 22 per cent wet basis, nearly dry, the same plugging situation was encountered. Similar results were expected within this wide range of moisture content and yields of almost one ton per acre, or more.

Performance of the chopper appeared to be satisfactory as far as plugging was concerned in operations with dry hay in a very light windrow. This was tried in wheat stubble with a small growth of alfalfa and grass and a sizeable percentage of wheat straw. The yield of dry hay was about one-half ton per acre.

Pickup of material from the windrow was not entirely satisfactory. An estimated 10 per cent of the forage was left on the ground (Figure 11). The amount lost appeared to be proportional to the size of the windrow and independent of the moisture content.

Removing Hay from Swath

Forage was removed from the swath with less difficulty than from the windrow. Here the amount of forage entering the machine could be controlled by using less than the full width of cut; the same as for a standing crop. Hay with a moisture content of approximately 40 per cent was used. Some difficulty was experienced with forage wrapping on the fan. This wrapping, however, would not stall the machine when the feed could be controlled. The forage left on the ground was about the same as with the windrow (Figure 12). This loss of 10 per cent would make the operation unsatisfactory.

FIGURE 9. Plugged vertical rotating flail harvester after attempting to pick up a windrow. Forage moisture content was estimated at 40 to 50 per cent wet basis. The manufacturer did not intend for the machine to do this job.

FIGURE 10. Removing forage from the blower of the vertical rotating flail harvester after attempting to pick up a windrow. The slowest possible forward speed was used (1.8 mph) with additional slipping of the tractor clutch. Estimates of the forage moisture content were 40 to 50 per cent wet basis.

FIGURE 11. Forage remaining in a windrow after pick up with the vertical rotating flail harvester. The handful of forage was collected between the two arrows. Estimated loss was 10 per cent.

FIGURE 12. Forage remaining in the swath after pick up with the vertical rotating flail harvester. Unrecovered cut forage has been raked forward from the clip-board to better show the amount missed, which was estimated to be 10 per cent.

Silo Filling

Silage involves crops of varying heights. The harvester with horizontal rotating flails could not handle tall forages to be used for silage. The vertical rotating flail harvester would handle material up to eight feet high. This was the tallest corn in which the machine was tested (Figure 13). Losses in this corn amounted to approximately 3 per cent. Ears, stalks and leaves appeared to be lost in near equal proportions (Figure 14).

The length of cut proved to be the greatest disadvantage in making silage with crops cut by the vertical rotary flail harvester. Although the material would pack so that it would properly ensile, it was difficult to remove the silage for feeding. The silage would hang together and cause excessive work for a man forking it. When the silage was forked into a mechanical feeding device, a screw for a bunker feeder would clog and would require excessive power.

No apparent difficulty was encountered with self-feeding in a box silo. Here the silage was not moved except by the cattle. Blowers moved the long-cut material at a slightly reduced rate from conveniently-chopped silage, but with no other difficulties. They could be used either for tower or bunker silos. A farmer could use the flail harvesters for silage on a limited scale if he would not object to the excessive labor in removing the silage.

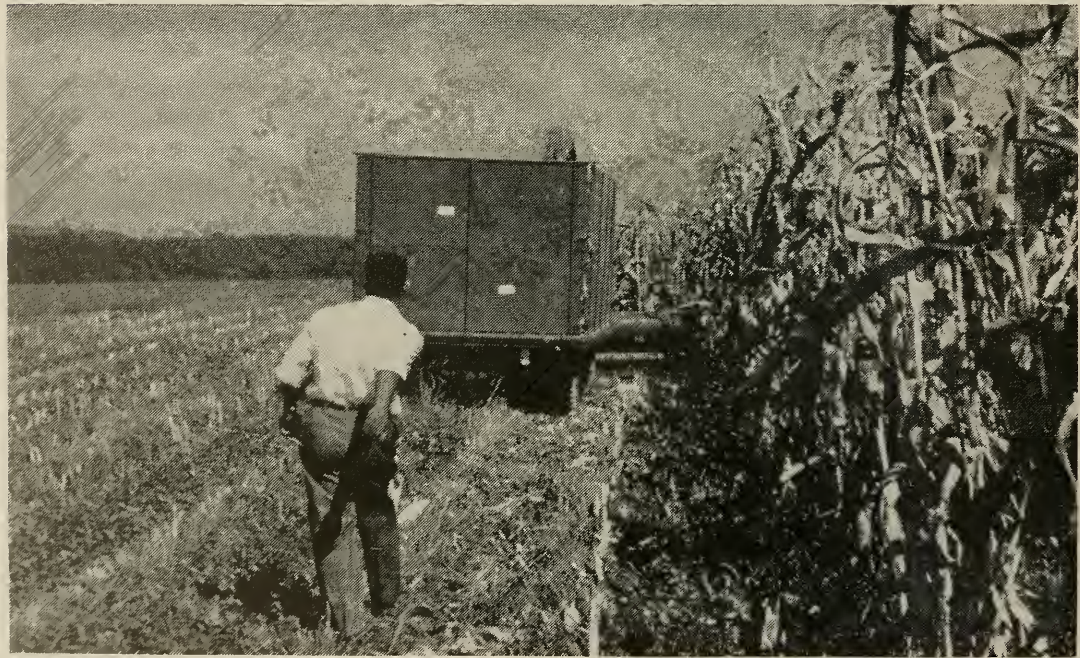

FIGURE 13. Vertical rotating flail harvester operating in corn.

FIGURE 14. Corn forage lost by the vertical rotating flail harvester during harvest. Two rows next to the standing corn were harvested with the rotary harvester, and the other row was harvested with a conventional field forage chopper. Estimated losses of the corn cut by the rotary harvester were 3 per cent of the total crop.

Pasture Trimming

Both the horizontal and vertical rotating flail machines worked quite well for pasture trimming. Such trimming left the field with a uniform stubble about three to four inches high, which was quite desirable. Briers and small brush (less than one inch in diameter at the base), which were not too frequent, were handled very easily. However, stones (Figure 1), mounds of earth such as ant hills, occasional brush larger than one inch in diameter, and similar obstructions would cause excessive damage to the machines. Earth mounds and small rocks were missed by higher cuts; however, such cuts made the pasture clipping less effective. Damage consisted of either shearing off the knives, which were rigid on the horizontal chopper (no effect on flexible flails), or excessive bending of the light housing of the machines. Brush cutting was not feasible with either machine due to these limitations.

(Turn Page for Conclusions)

Conclusions

The horizontal rotating flail harvester was satisfactory for removing standing crops not over 12 to 15 inches in height. The vertical rotating flail harvester removed any standing hay crop satisfactorily and removed corn with minor losses. Cutting for direct feeding was satisfactory. The length of cut was longer than that considered desirable for silage, but this may not be too great a handicap where only a small amount of silage is to be made. Forage cut for hay cured at an increased rate if it was turned and weather conditions were favorable. This method of haymaking was not desirable for general conditions. The flailed material can be removed from the field with a rake and baler. The rotary flail choppers are not satisfactory for pickup of cured hay because of excessive losses. Each machine was satisfactory for pasture clipping.